Analysis of Marine Boundary Layer Phase II Data

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LONG-TERM GOALS

The long-terms goals of the research are to understand and parameterize the physics of air –sea interaction, and in particular wind-wave interaction. The effort is primarily experimental, based on measurements over the sea under a variety of wind-wave conditions. Seven gigabytes of data were obtained from the Marine Boundary Layers experiment from the Research Platform *FLIP*. Other related experiments utilize research aircraft to probe the marine atmospheric boundary layer (MABL).

OBJECTIVES

The objective is to develop similarity parameterizations of air-sea interaction and the MABL. Underlying this is the improvement of the basic understanding of wind-wave physics.

APPROACH

The approach is in-depth analysis of the wind, turbulence and wave data obtained in the Marine Boundary Layers ARI experiment from R/P *FLIP*. Approximately 7 gb of data were obtained. Spectral , statistical and other analyses are applied to the data to determine the physics of wind-wave interaction and parameterizations of air-sea interaction.

WORK COMPLETED

Phase averaging techniques were developed to extract the wave-coherent signals submerged in the larger turbulent wind signals. Hilbert transform and zero-crossing methods were applied to the MBL data set. The PhD thesis of Scott Miller was completed.

RESULTS

The main results center on the wind profile and the wave-coherent quantities. The wind profile shows in general less shear than predicted from Monin-Obhukov similarity theory and associated empirical constants obtained from over-land experiments. While the range of buoyant stability conditions in the MBL II experiment was not large, the dependence of the shear of the wind profile on stability is opposite from that over land. At neutral conditions (no buoyancy), the MBL II results do give a von Karman constant equal to 0.4, slightly larger than obtained in over-land experiments. This may be due to the lower roughness of the sea surface.

Wave-coherent results indicate the role of the ratio of the wind speed to the phase speed of the deep water gravity waves in MBL II. For waves traveling faster than the wind, there is some momentum

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(stress) transfer from the waves to the wind. For wind speeds faster than the wave speeds, momentum transfer is from the wind to the waves. The zero-crossing phase average technique was used to compare the open-ocean results from MBL II to those from well-known laboratory data for monochromatic waves. The comparisons generally showed good agreement.

IMPACT/APPLICATIONS

The impacts of the research will be in the improvement of the basic understanding of air-sea interaction processes, and in particular the physics of wind-wave coupling. The research will lead to better parameterizations of air-sea interaction, such as the wind stress, through incorporation of wave effects. The techniques developed for the detection of coupling of the wind field to relatively large waves (wind waves and swell) will be directly and immediately applicable to the wave generation problem which occurs at small wavelengths (gravity- capillary and capillary waves) when such measurements in the tough ocean environment become possible.

The results should have impact on wave forecasting models and large-scale weather models.

TRANSITIONS

The results of the research have been presented at seminars and conferences. Inquiries were made from contractors working on the problem of turbulent refractive index fluctuations over the ocean.

RELATED PROJECTS

The research has spawned the investigation and development of sensors to make crucial wind and turbulence measurements closer to the ocean surface over the open ocean in the presence of large waves that will swamp and damage most traditional sensors. Through a DURIP project a Laser Doppler Anemometer was obtained and is a testing program is under development.

The phase averaging techniques developed may have applications in other areas where near-periodic signals are buried in noise; e.g., climate fluctuations, rotating machinery, etc.

PUBLICATIONS

Journal Papers:

Serra, Y. L., D. P. Rogers, D. E. Hagan, C. A. Friehe, R. L. Grossman, R. A. Weller, and S. Anderson, ``Atmospheric Boundary Layer over the Central and Western Equatorial Pacific Ocean Observed During COARE and CEPEX," J. Geophys. Res. (Oceans), 102, no. C10, 23217-23237 (1997).

Walsh, E. J., D. C. Vandemark, C. A. Friehe, S. P. Burns, D. Khelif, R. N. Swift, J. F. Scott, ``Measuring Sea Surface Mean Square Slope with a 36-GHz Scanning Radar Altimeter," J. Geophys. Res. (Oceans), 103, no. C6, 12,587-12,601 (1998).

Walsh, E. J., D. E. Hagan, D. P. Rogers, R. A. Weller, C. W. Fairall, C. A. Friehe, S. P. Burns, D. Khelif, D. C. Vandemark, R. N. Swift, and J. F. Scott, ``Observations of Sea Surface Mean Square Slope Under Light Wind During the Tropical Ocean-Global Atmosphere Coupled Ocean-Atmosphere Response Experiment," J. Geophys. Res. (Oceans), 103, no. C6, 12,603-12,612 (1998).

Fuehrer, P. L. and C. A. Friehe, ``A Physically-Based Turbulent Velocity Time Series Decomposition," Boundary-Layer Meteorology, in press (1998).

Khelif, D., S. P. Burns and C. A. Friehe, ``Improved Wind Measurements on Research Aircraft," J. Atmos. and Ocean. Tech., in press (1998).

Miller, S. D., J. Edson, T. Hristov, C. A. Friehe and S. Wetzel, "Wind and Turbulence Profiles over Open Ocean Waves," in 'Wind-Over-Waves Couplings: Perspectives and Prospects,' Institute of Mathematics and Its Applications, in press (1998).

Hristov, T., Miller, S. D., J. Edson, C. A. Friehe and S. Wetzel, "Structure of the Atmospheric Surface Layer over Open Ocean Waves: Representation in Terms of Phase Averages," in 'Wind-Over-Waves Couplings: Perspectives and Prospects,' Institute of Mathematics and Its Applications, in press (1998).

PRESENTATIONS

"Wind Over Waves," Institute of Oceanology, Qingdao, P. R. China, Dec. 23, 1997.

"Wind and Turbulence over Ocean Waves," GALCIT Fluid Mechanics Seminar, California Institute of Technology, May 22, 1998.

"Wind, Wave and Turbulence over Ocean Waves," Department of Atmospheric Sciences, Nanjing University, Nanjing, P. R. China, June 24, 1998.

IN-HOUSE/OUT-OF-HOUSE RATIOS

100% of the research work is done out-of-house, in an academic institution.